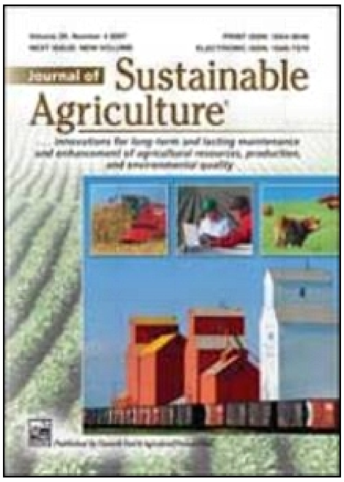

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Seasonal and Management Impact on Broiler Cake Nutrient Composition

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Seasonal and Management Impact on Broiler Cake Nutrient Composition

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ABSTRACT. Broiler "cake," which is the by-product of broiler manure management practice, is directly applied to pasture or crop lands. We studied the impact of season and broiler producers' management on broiler cake nutrient content from three commercial broiler producers. Broiler cake pH ranged from 7.0 in the summer to 8.3 in the winter among all producers. The cake total nitrogen (TN) and phosphorus (TP) were significantly impacted by season for all producers. Total N ranged from 34.8 in the spring to 43.6 g kg^{-1} in the winter while TP ranged from 16.96 in the winter to 19.80 g kg^{-1} in the spring. Broiler cake NH_4-N content ranged from 5.78 to 15.5% of the TN for all seasons and producers. Broiler cake generated in the spring and summer contained more Ca, Mg, K, Cu, Fe, and Mn than in the fall and winter. The results provide on-farm site specific information that may help producers and nutrient planners in relation to broiler cake application rate and timing.

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INTRODUCTION

The quantity of broiler (chicken, *Gallus gallus domesticus*) manure produced as a by-product of the poultry industry is substantial. In 2000, the U.S. broiler industry produced 7.2 billion broilers and generated more than 13 million metric tons of litter (Georgia Agricultural Statistics Service, 2000). Poultry manure is an important "commodity" that can reduce the demand for chemical fertilizers by providing many macro- and micronutrients for plant growth (Van Kessel et al., 2000). Return of the animal manure to land completes a natural sustainable recycling process. However, manure is also known to be a potential source of pollution to the environment (White, 1979; Sommerfeldt and Chang, 1985). Furthermore, excessive and untimely application of manure causes the accumulation of certain nutrients in the soil, which may ultimately be transported by runoff water or soil erosion to water bodies (Sauer et al., 1999; Codling et al., 2000). If manure is improperly managed, it can become a liability by creating environmental problems rather than a valuable resource (Edwards and Daniel, 1993; Pitts et al., 1997). How manure is managed, is a critical factor that affects the value of this resource (Stephenson et al., 1990; Tisdale et al., 1993). A better understanding of the impact of manure management, nutrient composition, and application timing is necessary if this important commodity be fully utilized (Sutton, 1994; Cabrera and Gordillo, 1995; Robbins et al., 2000).

Current broiler manure/litter management involves two methods of broiler house cleaning. Historically, after eight to ten cycles (flocks), the broiler house is cleaned to the ground–"total cleanout"–and the litter (manure plus bedding materials) is replaced with fresh bedding materials such as wood shavings. A more recent management practice, called "decaking," involves the removal of broiler "cake," which is the fresh broiler manure combined with some bedding materials and spilled feed. After each flock is harvested, the cake is separated from the bedding materials by passing the cake and the dry bedding materials over a grate that allows the fine materials to pass through and remain in the house while collecting the larger aggregates of caked materials in a hopper. The separation of cake from litter (decaking) is performed using specialized equipment called "Housekeeper®," which is pulled by a tractor. With this new management practice, producers do not have to replace the entire bedding materials for many years; instead, periodically small quantities of the fresh bedding materials is added to compensate for the amount removed with the cake. Information regarding characterization of broiler cake in contrast to broiler litter is lacking in the literature.

OBJECTIVE

The objective of this study was to determine the effect of season and broiler producer management on broiler cake nutrient composition. Since only broiler cake samples were collected for chemical analysis in this study, here on we only refer to broiler cake in place of broiler manure/litter.

MATERIALS AND METHODS

Broiler Litter and Cake Quantification

Three broiler producers from Smith and Leake Counties in Mississippi were selected as cooperators in this study. Two of the producers have been raising chickens for more than 20 years and the third one for three years. The producers own six poultry houses each with the capacity of accommodating between 20 to 25 thousand birds per house. Two of the producers are managing their poultry houses according to the normal operation with regard to lighting and ventilation. However, the third producer operates according to the "black out" system in which, birds are kept in about 95% darkness to reduce the birds' movement, presumably enhancing the rate of weight gain. The three selected producers are managing their broiler manure by decaking. This operation is done after harvesting each flock (47-49 d). Three broiler houses were selected from each producer for a total of nine houses for this study. Composited broiler cake samples were collected from four flocks per year per producer, representing spring, fall, summer, and winter. The cake samples at each sampling time (after flock harvest) represented the broiler cake, which was used directly for land application. The cake samples were transported to the laboratory for chemical analyses. Preliminary chemical analysis of the broiler cake (wet basis/as is) as compared to air drying indicated losses of up to 11% (46 g kg^{-1} vs. 41 g kg^{-1}) for N, and 5% (367 g kg^{-1} vs. 350 g kg^{-1}) for C. No other nutrient was impacted by air drying. These results were inline with other studies (Wood and Hall, 1991; Sistani et al., 2001). Hence, in order to sub-sample very small-uniform quantities of fresh broiler cake for N determination, we decided to air dry the samples in a ventilated glass-roofed greenhouse, then grind to pass a 1-mm screen prior to chemical analyses.

Chemical Analyses

The following chemical analyses were performed on all the samples. The pH was measured in the 1:5 cake:water ratio. Total N (TN) and total carbon (TC) were measured by the dry combustion method using CE Elantech CN analyzer. Nitrate nitrogen (NO_3-N) and ammonium nitrogen (NH_4-N) were extracted with 0.01 M KCl (1:15 manure:KCl) and analyzed with a Dionex-500 Ion Chromatograph (IC) using a modified procedure of Keeney and Nelson (1982). Total phosphorus (TP), potassium (K), calcium (Ca), magnesium (Mg), copper (Cu), iron (Fe), manganese (Mn), and zinc (Zn) were analyzed with a Thermo Jarrell-Ash Inductively Coupled Plasma Spectrophotometer (ICP), after dry ashing 0.5 g manure in a muffle furnace at 500ºC for 4 hours. This was followed by the dissolution of the ash first in 1 mL of 6 N HCl then by a mixture of 0.025 N H_2SO_4 and 0.05 N HCl (Southern Cooperative Series, 1983). Cake samples were also extracted with deionized water (1:15 manure:water), shaken for 30 min, filtered through 2V Whatman brand filter paper for water extractable P (WP), and analyzed by ICP. The samples were not filtered through a 0.45 µm filter, because our objective was to determine the total water extractable portion of P in the cake rather than only "soluble reactive" portion (Self-Davis and Moore, 2000).

Data were analyzed statistically, using analysis of variance (SAS, 1998) and then Tukey's test was applied to separate means at 0.05 probability level. Statistical analysis of the data showed significant differences among producers, which reflects the management differences among commercial broiler growers. Therefore, the data were analyzed and presented separately by producers, except for general statements regarding broiler cake nutrient content. It should also be noted that all the samples collected were broiler cake, except where mentioned, litter for comparison purposes.

RESULTS

The pH of broiler cake ranged from 7.0 to 8.3 for all producers and seasons. Significant seasonal differences in cake pH were not consistent among producers. However, broiler cake pH was consistently lower in the summer than the other seasons. The seasonal pH of broiler cake for producer 3 (blackout system) was consistently lower than producers 1 and 2 (Table 1).

Broiler cake total carbon (TC) ranged from 284 g kg^{-1} (producer 3) in winter to 368.4 g kg^{-1} (producer 1) in the spring. The cake TC content was greater in the summer and fall than winter and spring. There were significant differences in broiler cake total nitrogen (TN) among seasons and producers (Figure 1). Broiler cake TN ranged from 34.6 g kg^{-1} in the summer to 43.6 g kg^{-1} in the winter for all producers. No particular trend was observed among seasons for each producer. For example, the lowest broiler cake TN for producer 1 was

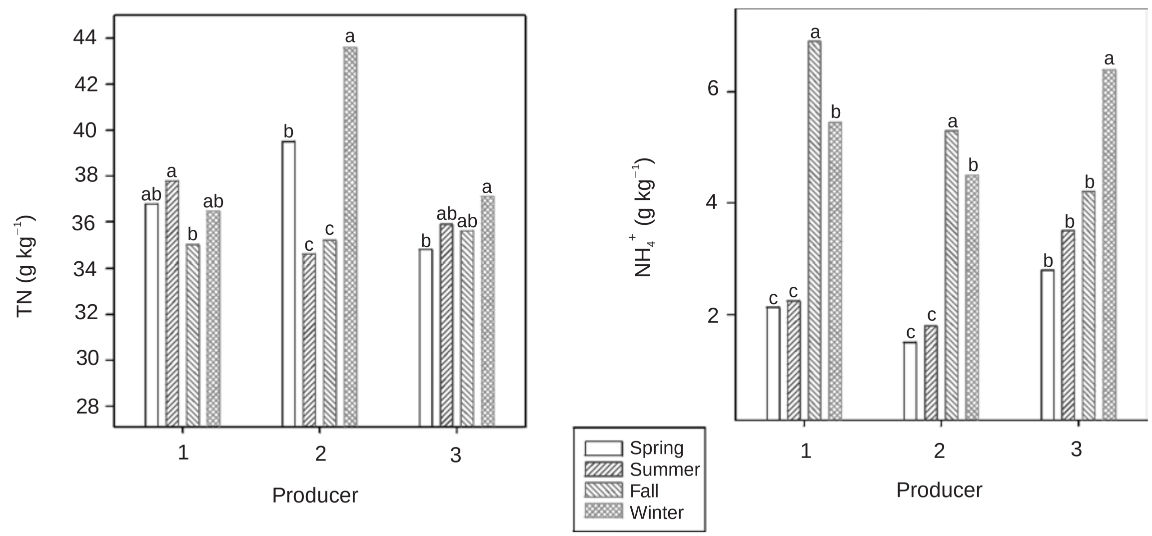
TABLE 1. Broiler cake pH and nutrient composition for different producers and seasons.†

Variables		pH	TC	NO_3-N	Ca	Mg
			-------------------g kg^{-1}	------------------		
Producer 1	Spring	7.8 a*	368 a	0.40 b	27.0 a	6.3 a
	Summer	7.4 b	361 a	0.75 a	27.6 a	6.5 a
	Fall	7.6 a	360 ab	0.14 b	24.2 b	5.7 b
	Winter	7.8 a	350 b	0.28 b	23.5 b	5.5 b
Producer 2	Spring	7.6 b	309 c	0.99 a	28.2 ab	6.7 b
	Summer	7.5 b	340 b	0.72 a	29.3 a	7.2 a
	Fall	7.7 b	356 a	0.05 b	23.7 c	5.7 c
	Winter	8.3 a	329 b	0.68 a	27.4 b	6.3 b
Producer 3	Spring	7.2 a	319 b	0.64 ab	22.4 b	6.2 a
	Summer	7.0 b	359 a	0.79 a	23.8 a	6.4 a
	Fall	7.4 a	286 c	0.09 c	20.1 d	5.2 c
	Winter	7.2 a	284 c	0.48 b	21.2 c	5.8 b

†Data Points are average of four sampling times per flock (one flock per season) per producer.
*Values followed by the same letter in each column for each producer are not significantly different at 5% level according to Tukey's test.

in the fall, while for producers 2 and 3 were in the summer and spring, respectively. Cake TN content was the greatest in the winter for producers 2 and 3, and in the summer for producer 1. The greater TN content of broiler cake during winter may be attributed to the higher moisture content, which reduces the loss of N as NH_3 volatilization. The NH_4-N content of broiler cake followed a similar trend for all producers (Figure 1). Broiler cake generated during spring and summer contained significantly less NH_4-N than fall and winter. Averaged across the three producers, cake NH_4-N as a percent of TN was 5.7% for spring, 6.9% for summer, 12.7% for fall, and 14.1% for winter. This indicates that the potential for NH_3 losses from the broiler house is greater in the fall and winter, which may have air quality implication. Broiler cake NO_3-N content was very small compared to NH_4-N. Broiler cake NO_3-N ranged from 0.05 g kg^{-1} to 0.99 g kg^{-1} for all producers and seasons (Table 1). In contrast to NH_4-N, the NO_3-N content of the broiler cake was consistently greater during spring and summer than during fall and winter for all producers. Climatic factors such as moisture and temperature of the air inside the broiler house, which affect microbial activities, ammonia volatilization, and nitrifica-

FIGURE 1. Seasonal impact on broiler cake total N (TN) and ammonium nitrogen (NH_4^+-N) for three broiler producers. Data points are averages of four sampling dates per flock per season for each producer. Bars with different letters within each producer are not significantly different at the 5% level according to Tukey's test.



tion processes, are considered to be responsible for greater NO_3-N in spring and summer.

Broiler cake total phosphorus (TP) varied significantly among seasons for all producers (Figure 2). The broiler cake TP content was greatest in the summer followed by spring, fall, and winter consistently, except for producer 2, in which the cake TP content was greater in the winter than in the fall. The broiler cake greatest TP (21.0 g kg^{-1}) was determined in the summer for producer 2, while the lowest (16.96 g kg^{-1}) was in the winter for producer 3. We believe that the seasonal differences in the broiler cake TP content may be related to the bird's ability to utilize the feed supplemental inorganic P during different seasons. It is important to know the quantity of broiler cake TP that is water soluble (WP), since WP is easily transported by runoff water, which may cause environmental problems. The WP ranged from 1.7 g kg^{-1} in the fall to 4.1 g kg^{-1} in the winter for all producers. Based on calculation from the data presented in Figure 2, the broiler cake WP as a percentage of TP was greater in the winter for producers 1 and 2, while it was greater in the spring for producer 3. Broiler cake generated from “blackout” management system (Producer 3) contained the lowest yearly average of TP (17.20 g kg^{-1}), compared to 18.33 g kg^{-1} and 19.5 g kg^{-1} for producers 1 and 2, respectively. However, broiler cake TP from the blackout system had greater percentage of WP (17.28%), compared to 13.65% and 14.52% for producers 1 and 2, respectively (Figure 2).

Tables 1 and 2 show the broiler cake metals nutrients content for different seasons. There were significant differences in broiler cake Ca, Mg, K, Cu, Fe, Mn, and Zn among seasons. In general, the broiler cake Ca, Mg, K, Cu, Fe, and Mn content were greater in spring and summer than fall and winter for all producers. The broiler cake Mg was less than Ca, and K. The broiler cake Cu, Fe, Mn, and Zn were less than 1 g kg^{-1} except Fe for producer 3, which was 1.45 g kg^{-1} the highest among all seasons and producers (Table 2).

For the purpose of reporting a generalized characterization of broiler cake nutrient content, the average value of each parameter, across all producers and seasons ($n = 108$) is presented as follows: pH 7.38, total carbon 34.27%, total nitrogen 3.76%, C:N = 9.11, ammonium nitrogen 4.26 g kg^{-1}, nitrate nitrogen 0.045 g kg^{-1}, total phosphorus 1.92%, N:P = 1.96, water-soluble phosphorus 3.22 g kg^{-1}, calcium 25.50 g kg^{-1}, magnesium 6.34 g kg^{-1}, potassium 33.37 g kg^{-1}, copper 657 mg kg^{-1}, iron 902 mg kg^{-1}, manganese 519 mg kg^{-1}, and zinc 424 mg kg^{-1}.

Wood and Hall (1991) reported the nutrient composition of air-dried broiler litter as follow: total carbon 275 g kg^{-1}, total nitrogen 29 g kg^{-1}, ammonium nitrogen 627 mg kg^{-1}, total phosphorus 15.2 g kg^{-1}, potassium 21.7 g kg^{-1}, copper 336 mg kg^{-1}, iron 727 mg kg^{-1}, and zinc 302 mg kg^{-1}. Stephenson et al. (1990) also reported the nutrient content of broiler litter; total nitrogen 40 g kg^{-1}, total phosphorus 15.6 g kg^{-1}, calcium 23.1 g kg^{-1}, potassium 23.2 g kg^{-1}, magnesium 5.2 g kg^{-1}, copper 473 mg kg^{-1}, iron 2377 mg kg^{-1}, manganese 348 mg kg^{-1}, and zinc 315 mg kg^{-1}. These numbers indicate that ex-

FIGURE 2. Seasoned impact on broiler cake total P (TP) and water extractable P (WP) for three broiler producers. Data points are averages of four sampling dates per flock per season for each producer. Bars with different letters within each producer are not significantly different at the 5% level according to Tukey's test.

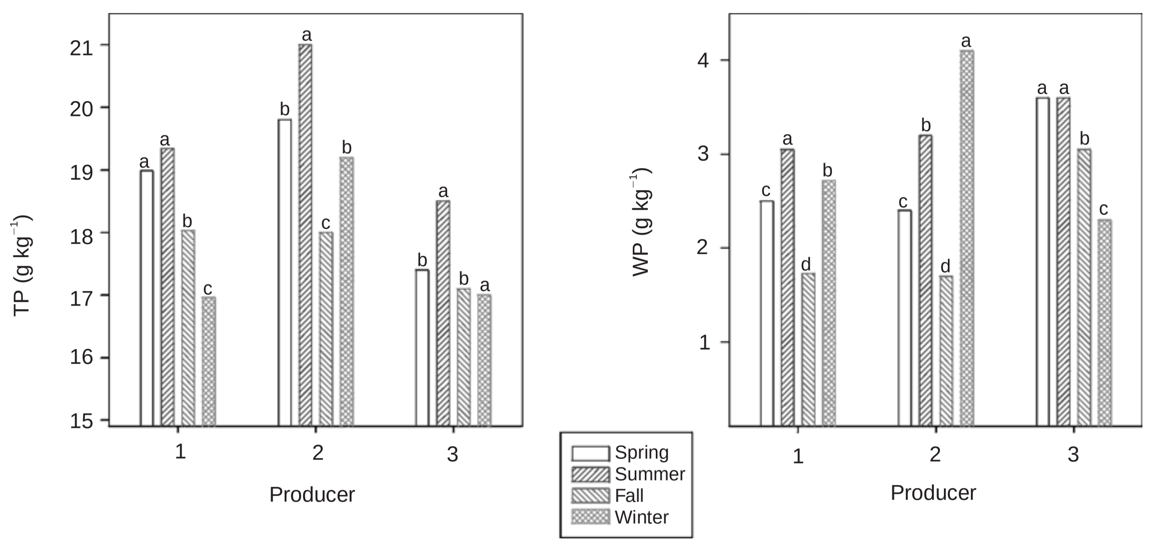


TABLE 2. Broiler cake nutrients composition for different producers and seasons.[†]

Variables		K g kg^{-1}	Cu	Fe	Mn	Zn
			---mg kg^{-1}---			
Producer 1	Spring	32 a*	594 b	768 a	574 a	464 a
	Summer	33 a	606 b	759 a	587 a	471 a
	Fall	31 a	722 a	636 b	566 ab	486 a
	Winter	30 b	622 b	587 b	533 b	460 a
Producer 2	Spring	32 b	633 b	900 ab	615 b	489 ab
	Summer	36 a	723 a	927 a	673 a	527 a
	Fall	30 c	683 ab	697 c	542 c	461 b
	Winter	30 c	650 b	829 b	619 b	518 a
Producer 3	Spring	32 b	805 a	1286 b	605 a	454 a
	Summer	34 a	824 a	1211 b	564 a	434 ab
	Fall	28 d	716 b	1404 a	494 c	370 c
	Winter	30 c	714 b	1450 a	550 b	410 b

[†] Data Points are average of four sampling times per flock (one flock per season) per producer.
[*] Values followed by the same letter in each column for each producer are not significantly different at 5% level according to Tukey's test.

cept for few exceptions, in general the nutrient content of broiler cake and broiler litter is very close. However, the composition may vary significantly depending on the age of litter and location.

DISCUSSION

The data in this experiment indicated significant differences in the nutrient composition of broiler cake generated at different seasons by different producers. Few nutrients were greater in the fall and winter, while others were greater in the spring and summer. Also, there were those elements that were greatest in only one season. This creates a challenging management practice for producers with regard to the utilization of broiler cake as an organic fertilizer for plant growth in a sustainable system. The information gained here may help producers to decide the proper timing of the broiler cake application to crop or pasturelands. Also, environmental problems may be avoided if the land application of broiler cake coincides with the time of vigorous plant growth and maximum demand for broiler cake nutrient content.

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